

# **MARKSCHEME**

**May 2000**

**CHEMISTRY**

**Higher Level**

**Paper 2**

# SECTION A

1. (a) (i) Endothermic/heat absorbed/energy absorbed / increase in enthalpy / needs (a lot of) energy [1]
- (ii)  $K_c$  is decreased / OWTTE. [1]  
Since heat is removed / since equilibrium moves to left / reverse reaction favoured. [1]
- (iii) 
$$\begin{array}{ccc} \text{N}_2 & + & \text{O}_2 \\ (1.6-x) & & (1.6-x) \end{array} \rightleftharpoons \begin{array}{c} 2\text{NO} \\ 2x \end{array}$$
 [1]  
$$K_c = \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]}$$
 [1]  
$$[\text{NO}] = 0.065 \text{ mol dm}^{-3}$$
 [1]  
(If candidate uses 1.6 instead of  $(1.6-x)$ , which gives an answer of 0.066, award [2] unless it is specifically stated that an approximation has been made or  $1.6 \gg x$ .)
- (b) (i)  $\text{O}_3$ : 1st order plus reasonable attempt to justify (e.g. double  $[\text{O}_3]$  doubles rate). [1]  
 $\text{NO}$ : 1st order plus reasonable attempt to justify (e.g. triple  $[\text{O}_3]$  and triple  $[\text{NO}]$ , rate is  $\times 9$ ). [1]  
(Two correct orders but no reasoning, award [1].)
- Rate =  $k[\text{O}_3][\text{NO}]$  (accept rate expression consistent with stated orders – ECF principle) [1]
- (ii)  $0.66 \times 10^{-4} = k \times 3 \times 10^{-6} \times 10^{-6}$  [1]  
 $k = 2.2 \times 10^7 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$  [1] [2]  
(Apply error carried forward (ECF) from rate expression in (i). U-1 may be applied.)
- (iii) Rate (experiment 4) =  $2.2 \times 10^7 \times 4.5 \times 10^{-6} \times 7.2 \times 10^{-6} = 7.13 \times 10^{-4}$  [1]  
**OR** Rate (experiment 4) = Rate (experiment 3)  $\times \frac{3}{2} \times \frac{8}{10} = 7.13 \times 10^{-4}$   
(Apply ECF from rate expression in (i), must be experiment 4, units not required.)
2. (a)  $\text{C}_3\text{H}_8$  has higher boiling point; [1]  
since it has greater  $M_r$  / greater number of electrons / greater number of carbons; [1]  
so greater intermolecular forces / more energy needed. [1]
- (b)  $\text{CH}_3\text{CH}_2\text{OH}$  has higher boiling point; [1]  
**hydrogen bonding** between molecules; [1]  
so more energy needed to separate molecules / so greater intermolecular forces. [1]

3. (a) Acidic because  $H^+$  donor and basic because  $H^+$  acceptor. [1]  
Suitable equation OWTTE involving water [1]

(b)  $O^{2-}$  /oxide ion (allow  $O^{-2}$ ) [1]

(c) Electrical conductivity **OR** pH meter (or indicator paper) [1]  
Strong: good conductor **OR** Strong: low pH [1]  
Weak: poor conductor **OR** Weak: high pH [1]  
(Allow full range indicator, do not allow litmus, use judgement on other methods.)

(d) Ratio of moles =  $60 \times 0.2 : 40 \times 0.15$  [1]  
(acid:alkali) = 2 : 1

Acid is in excess and reacts to form salt.  
Moles acid:moles salt = 1:1 [1]

$$K_a = \frac{[H^+][A^-]}{[HA]} / [H^+] = K_a \frac{[HA]}{[A^-]} \quad [1]$$

pH = 4.86 [1]

(Weak acid calculation based on excess acid giving a pH of 3.04 [3 max];  
Weak acid calculation based on total acid giving a pH of 2.89 [2 max];  
Solution based on  $\frac{1}{2}$  neutralisation worth [4];  
Working must be shown.)

4. (a) Reducing agent donates/loses electrons / OWTTE. [1]

(b) Current flow: Al  $\rightarrow$  Ni [1]  
Al  $\ominus$ , Ni  $\oplus$  (both) [1]

(c)  $2\text{Al} + 3\text{Ni}^{2+} \rightarrow 3\text{Ni} + 2\text{Al}^{3+}$  [2]

*(Award [1] for correct species on correct sides of equation and [1] for correct coefficients, even if equation reversed.)*

$E^\ominus = +1.43 \text{ V}$  [2]

*(Award [1] each for sign and value. Allow  $-1.43 \text{ V}$  if equation reversed – ECF principle. If signs not appropriate but value correct, award [1]. If  $E^\ominus$  values added, award [0].)*

(d) Seconds  $= 2 \times 3600$  OR 7200 [1]

Coulombs  $= 8 \times 2 \times 3600$  OR 57 600 [1]

$\div F = \frac{57\,600}{96\,480}$  OR 0.5970 [1]

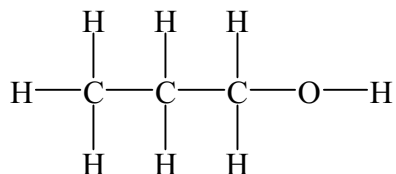
$\div 6 = \frac{57\,600}{96\,480 \times 6}$  [1]

Answer  $= 0.099\,50 = 0.10(00)$  [1]

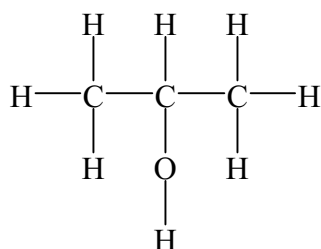
*(Correct answer with no working, [4 max].)*

### SECTION B

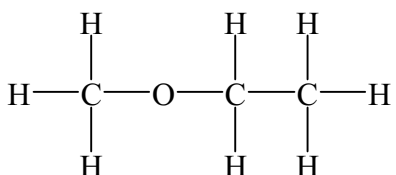
5. (a) (If lines are shown without H atom attached, penalise once only.)



1-propanol / propan-1-ol (I)  
(do not accept propanol)



2-propanol / propan-2-ol (II)



methoxyethane (III)  
(accept ether or alkoxyalkane)

3 × [1]

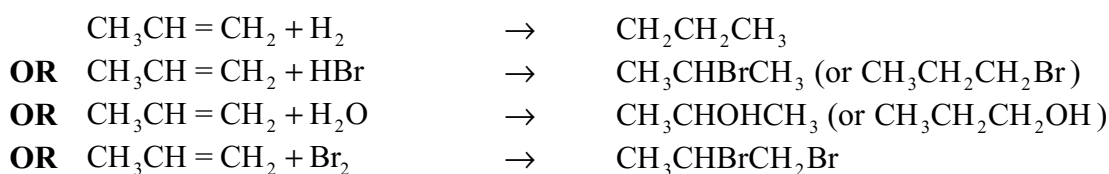
3 × [1]

- (b) (I) partially [1] oxidised [1] to CH<sub>3</sub>CH<sub>2</sub>CHO [1], propanal [1]  
(if state CH<sub>3</sub>CH<sub>2</sub>COOH propanoic acid instead of propanal, award [1])  
(II) oxidised (if not in (I), award [1]) to CH<sub>3</sub>COCH<sub>3</sub> [1], propanone [1]  
(I) or (II): orange to green [2]

- (c) alkanols show bands above 3000 cm<sup>-1</sup> [1]  
III is the choice [1]  
since it has C–O(–O) but no –O–H [1]

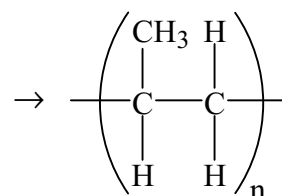
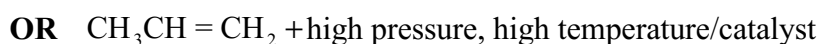
- (d) A is I [1] 3 Hs in CH<sub>3</sub>, 2 Hs in adjacent CH<sub>2</sub>, 2 Hs in next CH<sub>2</sub>, 1 H in OH [1]  
B is II [1] 6 Hs in the two CH<sub>3</sub>s, 1 H in CH, 1 H in OH [1]

- (e) I and II [1]  
both give CH<sub>3</sub>CH = CH<sub>2</sub> / CH<sub>3</sub>CHCH<sub>2</sub> [1]



Reagents [1]

Product [1]



idea of polymerisation [1]

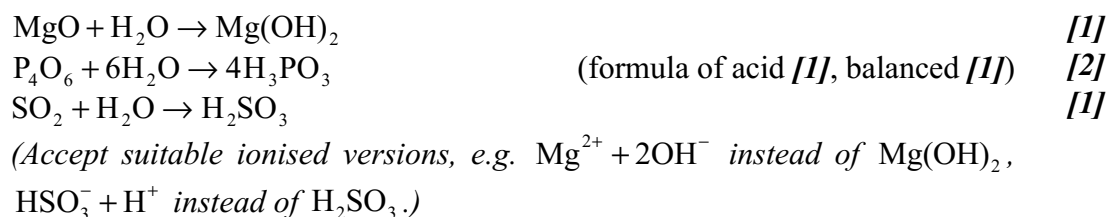
content of bracket [1]

6. (a) (i) MgO ionic [1]  
 SiO<sub>2</sub> covalent [1]  
 both giant structures [1]  
 ionic bonds strong [1]  
 covalent bonds strong [1]  
 P<sub>4</sub>O<sub>6</sub> simple molecular [1]  
 SO<sub>2</sub> covalent [1]  
 weak intermolecular forces / bonds [1] [8]

(ii)

Oxide	Solubility	Acidic/Alkaline/Neutral
Magnesium	Soluble	Alkaline
Silicon	Insoluble	Neutral
Phosphorus	Soluble	Acidic
Sulphur	Soluble	Acidic

4 correct = [3]      4 correct = [3]  
 3 correct = [2]      3 correct = [2]  
 2 correct = [1]      2 correct = [1]      **max [6]**



- (b) Ti 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>4s<sup>2</sup>3d<sup>2</sup> / [Ar] 4s<sup>2</sup>3d<sup>2</sup> [1]

Variable valency / oxidation

state / OWTTE [1] removal/sharing of several electrons [1]  
 coloured compounds [1] splitting of d orbitals, electron transitions [1]  
 complex compounds [1] accepting of electron pairs [1]  
 catalytic activity [1] complex formation/change of valency/can  
 easily be oxidised or reduced [1]

any three [3]  
 plus appropriate reason [3]

7. (a) (i)  $\Delta H^\ominus$  is positive [1]  
Reaction is endothermic (because products are at higher energy) [1]  
Bonds in reactants must be stronger than those in products (because more energy must be added than is released). [1]

(ii)  $\Delta G^\ominus$  is negative [1]  
because reaction is spontaneous [1]  
 $\Delta S^\ominus$  is positive [1]  
Since  $\Delta H^\ominus$  is positive,  $\Delta S^\ominus$  must be positive in order to make  $\Delta G^\ominus$  negative. [1]  
( $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$ ) [1]  
Products must be more disordered than reactants. [1]

(iii) **Known volumes** of reactant solutions at the **same temperature** are mixed and **temperature is monitored.** [3]  
Mol of limiting reactant calculated from volume and **known concentration.** [1]  
 $q = \Delta T \times \text{mass of solution} \times C_p$  [1]  
 $\Delta H = q \text{ mol}^{-1}$  of limiting reactant [1]  
Use of insulated reaction vessel [1]  
Stir the mixture [1]

**Note:** [6] max which **must** include:  
(a) known concentration of one volume;  
(b) excess or equal reacting mols of second solution;  
(c) temperature change;  
(d)  $q = \text{mass} \times \text{specific heat capacity} \times \Delta T$

(iv) If reactants do not react completely. [1]  
If container is not insulated adequately, **heat will be gained from surroundings.** [1]  
Insulate container sufficiently. [1]



(v) Reaction becomes more spontaneous as  $T$  is increased [1]  
less spontaneous as  $T$  is decreased. [1]  
 $T\Delta S^\ominus$  term will become larger as  $T$  is raised so  $\Delta G^\ominus$  will become more negative. [1]  
 $T\Delta S^\ominus$  term will become smaller as  $T$  is lowered so  $\Delta G^\ominus$  will become less negative (or even positive as  $+\Delta H^\ominus$  exceeds  $T\Delta S^\ominus$ ). [1]  
(Accept arguments based on Le Chatelier's principle.)

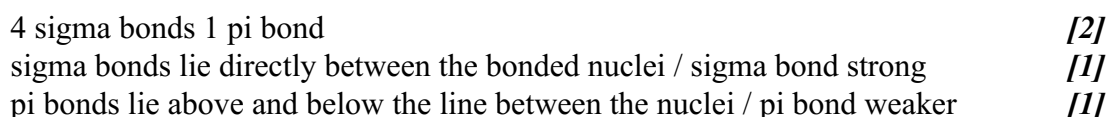
(b) (i)  $\Delta H_{\text{reaction}} = 2(\text{A—A}) \text{ bond energy} + \text{B—B bond energy} - 4(\text{A—B}) \text{ bond energy}$  [2]  
[1] for correct signs [1] for correct coefficients  
(Number of bonds should be clear.)

(ii) Tabulated bond energies are average values and may differ from those in specific compounds. [1]  
The best agreement is achieved when few bonds are broken / specific bond energies are used / for gaseous reactions. [1]



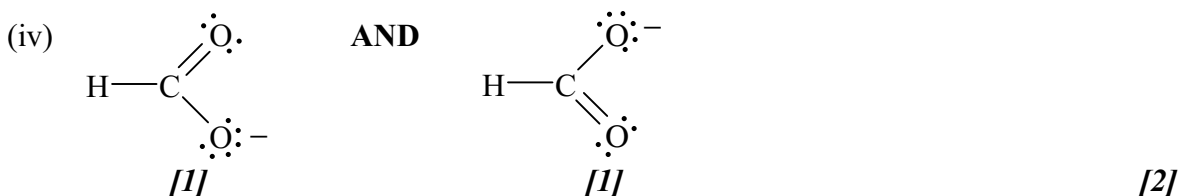
- (iii)  $\text{N}_2$  –  $\text{sp}$  hybridisation,  $\text{NH}_3$  –  $\text{sp}^3$  hybridisation,  $\text{HNNH}$  –  $\text{sp}^2$  hybridisation  
[1] each [3]

- |   |   |                            |
|---|---|----------------------------|
|  |  | <i>[1] each</i> <i>[2]</i> |
| nonpolar  | polar   | <i>[1] each</i> <i>[2]</i> |



- (ii) one longer than the other [1]  
 $\text{C}=\text{O}$  shorter/extra  $\text{e}^-$  pair makes bond shorter. [1]

- (iii) C—O bonds of same length [1]  
because of delocalisation / idea of resonance. [1]



(Negative charge omitted – no penalty, electrons on O omitted – [0].)  
Intermediate bonding or other sensible alternative statement. [1]  
(Accept 1½ bonds /  $\pi$  electrons spread across C—O bonds.)